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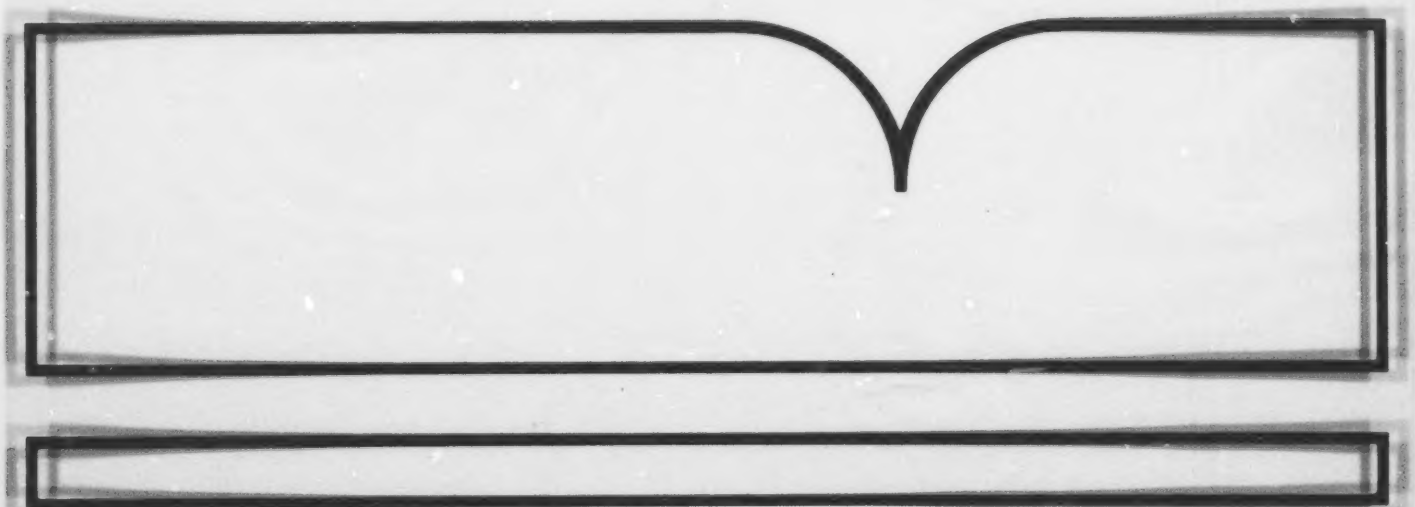

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ASSESSING POTENTIAL EFFECTS OF INCINERATING HAZARDOUS WASTES AT SEA: DEVELOPMENT AND FIELD-TESTING OF THE MARINE BIOLOGICAL ASSESSMENT SAMPLER

By

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16. ABSTRACT The paper discusses the development and field-testing of the Marine Incineration Biological Assessment Sampler (MIBAS), used to assess potential effects of incinerating hazardous wastes at sea. In 1985, the U.S. EPA developed a strategy for the research necessary for measuring environmental and public health effects of incinerating hazardous wastes at sea. One area of this strategy addressed developing a way to sample incinerator emissions and introduce them into seawater for use as test media in toxicity tests. Responding to the strategy, EPA developed the MIBAS system, a system that samples incineration flue gas, cools the emissions, and collects them in seawater-filled impingers. Particulate matter and both semivolatile and nonvolatile organic species are collected by the train. The sample for use in toxicity tests includes the contents of the impingers, the probe, a flexible Teflon line, and a condenser coil. The system uses no materials that could in themselves prove toxic to marine organisms. A recent modification of the train permits collecting emissions in the first impinger without bubbling, mimicking the situation in nature, where emissions would settle onto the ocean surface. MIBAS tests have included spike-recovery, using a gas-phase spiking system to spike compounds into the emissions and then measuring them in the components of the MIBAS train.

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ABSTRACT

In 1985, the U.S. Environmental Protection Agency (EPA) developed a strategy to address the research necessary for measuring possible environmental and public health effects of incinerating hazardous wastes at sea. One area of this research strategy addressed development of a method to sample incinerator emissions and introduce them into seawater for use as test media in toxicity tests. In response to the research strategy, EPA has developed the Marine Incineration Biological Assessment Sampling (MIBAS) system.

The MIBAS system samples incineration flue gas, cools the emissions, and collects them in seawater-filled impingers. Particulate matter, semivolatile organic species, and nonvolatile organic species are collected by the train. The sample taken for use in toxicity tests includes the contents of the impingers plus the contents of the probe, a flexible Teflon line, and a condenser coil.

The system uses no materials that could in themselves prove toxic to marine organisms. A recent modification of the train has provided for collection of emissions in the first impinger without bubbling, mimicking the situation in nature whereby emissions would settle onto the surface of the ocean.

The MIBAS system has been evaluated through a series of tests conducted at the Battelle Multifuel Furnace in

Columbus, Ohio, and the EPA Combustion Research Facility in Jefferson, Arkansas. These tests have included spike-recovery experiments using a gas-phase spiking system to spike compounds into the emissions and then measuring them in the components of the MIBAS train.

INTRODUCTION

As part of the U.S. Environmental Protection Agency's (EPA) consideration of ocean incineration of hazardous wastes as a waste disposal option, EPA has formulated an overall research strategy (EPA, 1985). The major focus of the strategy is the development of a rational, scientifically defensible methodology of an updated assessment of environmental and public health risks associated with ocean incineration. One area of research, designated as Study Area 1, involves development of methods for sampling emissions for chemical characterization and for use in toxicity testing. There is a significant difference between assessing risk associated with effects of a specific hazardous compound and that associated with a complex mixture, such as the incinerator emissions of a hazardous waste incinerator. Incinerator emissions are difficult to sample at high temperatures, may exist in two phases (emissions gases and scrubber water), and are not easily characterized. This paper describes the method developed to sample stack emissions and introduce them to seawater for use in toxicity tests.

ALTERNATIVES CONSIDERED AND SAMPLING SYSTEM SELECTED

Because the purpose of the sampling system was to provide samples for use as test media in aquatic toxicity tests, the system had to be designed to produce samples that would simulate ocean water after exposure to incinerator emissions. It could not introduce materials that would in themselves prove hazardous to marine organisms, and it had to be capable of collecting appropriate volumes of emissions to be able to test realistic concentrations of emissions constituents.

The system had to be rugged enough to be used at sea and made of readily available materials so that repairs could be made in the field. It had to be resistant to corrosion so that it could be used at sea, aboard an incinerator vessel. Because collection of emissions samples also results in collection of hydrochloric acid (HCl) and water vapor, the system had to be able to accommodate the extra volume of material that would be collected.

One possible design for the system was a packed-bed demister train, This system uses a countercurrent, cascade scrubbing procedure to collect particulate emissions. Gaseous emissions are passed through a seawater tank, and residual water is removed in a silica gel impinger. This type of sampling system was rejected from consideration, because the technology was untested, and the ability to achieve intimate mixing between gas and liquid

phases was uncertain.

Another system that was considered was a large liquid tank with dispersed bubble sparging. In this system, gaseous emissions are initially bubbled through ocean water contained in a large tank. A second tank collects any overflow from the first tank. The second tank is followed by a silica gel trap, a dry gas meter, and a vacuum pump. This system was not used, because the design was untested in stack gas sampling, and because it suffers from having only a single gas-liquid exposure.

Cryogenic sampling techniques were excluded, because the thermal fluctuations involved in freezing and thawing could modify many of the chemicals potentially present in incinerator emissions. Resin sampling techniques were also excluded, because they require either heat, which could decompose compounds of interest, or solvent flushing, which would render any sample unsuitable for use in toxicity tests.

The sampling system selected was based on the EPA Source Assessment Sampling System (SASS) impinger train, modified for direct seawater impingement and condensation. The modified system was renamed the Marine Biological Assessment Sampler (MIBAS). Because the system is a modification of an existing system, ruggedness, corrosion protection, availability of materials, and ease of transportation have already been demonstrated. The train did, however, require testing for completeness of collection

in a seawater matrix.

DESCRIPTION OF THE MIBAS TRAIN

The MIBAS train, as originally configured, includes a flexible Teflon sample line, a water condensation coil, three glass impingers containing seawater, an XAD-2 adsorbent trap, a glass impinger containing a sodium hydroxide solution and acid indicator, an impinger with activated silica gel, a sampling pump, and a dry gas meter. The glass impingers fit neatly into an ice chest, allowing ease in handling and a continually cooled environment. The impingers, condenser, and sample line are held together by ball-and-socket joints, clamped with knurled nuts. Good sealing of the joints is attained without the use of stopcock grease.

The MIBAS train collects particulate matter, semivolatile organic species, and nonvolatile organic species. Cooled gas (<20°C) enters the first seawater-filled impinger through a tube with four openings. These openings allow direct impingement of gas and particulate material. The second impinger is an open tube. Any particulate material should be collected in these two impingers. The third impinger uses a coarse frit on the impinger tube to improve gas-seawater contact.

Recently, an additional impinger was added to the front

of the MIBAS train. To better mimic the settling and subsequent mixing of emissions constituents with seawater in the field, this impinger has a shortened stem that allows the sample to be collected with an initial minimum of bubbling.

The resulting sample for use in toxicity tests includes the contents of the emissions sampling probe, the Teflon coil, the condensing tube, and the seawater impingers, as well as seawater rinses of these components. The XAD-2 resin is present to collect any organic analytes that may pass through the seawater impingers. Solvent rinses of the train are also used to measure any organic species adhering to the sampling system.

VALIDATION OF THE MIBAS TRAIN

Validation of the MIBAS train has included experiments using simulated flue gas, fuel oil burns, and hazardous waste burns at Battelle's Multifuel Furnace in Columbus, Ohio, and at the EPA Combustion Research Facility in Jefferson, Arkansas.

The simulated flue gas tests were conducted to determine performance and limitation of the MIBAS train. Tests conducted have included seawater blanks, HCl challenge tests, time trials, and precision tests. Seawater blanks were used to determine whether the system could be subject

to unacceptable contamination. Simulated flue gas spiked with HCl was used to demonstrate the impact of the highly acidic environment on collection by the train. Time trials were used to determine an optimum sampling time for collection of a sample that would be of appropriate concentration for use in toxicity tests. Precision tests were conducted to define the limits for the system.

Tests of the system using fuel oil were conducted as a system "shakedown," to determine whether the system could be used in a field situation such as would be encountered at sea. Toxicity tests were conducted in a mobile toxicology laboratory during the same period.

Validation of the system in a series of waste burns is being conducted to further challenge the test protocols and to provide a "range-finding" estimation of concentrations that affect test organisms. These tests have included a series of experiments in which known chemical compounds are spiked into the gas phase of the system during sampling and into the seawater impingers before and after sampling. Recovery of these compounds is used to judge trapping efficiency of the train.

Although validation of the MIBAS train is not complete, it appears that the train is a valuable tool for collecting emissions and using them in tests to assess the potential risks associated with incineration of wastes at sea.

REFERENCES

U.S. Environmental Protection Agency (1985) Incineration-at-sea research strategy. Washington, DC.